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WITNESS my hand this
Eighteenth day of March 2003

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THREE DIMENSIONAL JIGSAW PUZZLES

Aim:

To produce a 3D jigsaw puzzle that accounts for objects that have edges and surfaces that are both square and curved. The idea is to extend the concept of what can be a jigsaw puzzle while maintaining the identity and familiarity of a jigsaw puzzle. There are however, new pieces to accommodate the corners, edges and curves. For instance, as a traditional 2D jigsaw puzzle can be made from a picture of an apple, now a jigsaw puzzle might be the apple as a three dimensional object.

There are 3D jigsaw puzzles on the market. The main difference between these products and the product about to be explained is that there are pieces designed for three dimensional surfaces. One 3D jigsaw brand relies on the frictional resistance gained by making the pieces from a foam product. Using this means, a curved surface is made from 2D pieces that badly interlock in a finger jointed type arrangement. The other 3D jigsaw manufacturer uses 2D pieces that are similar looking to a normal jigsaw piece but have extra clasps on each side of the piece. This particular design only allows for the construction of spheres, something new in itself for the jigsaw market.

The jigsaw pieces described below include pieces designed for curved surfaces and smooth edges. It is a fundamental shift in what can be viewed as achievable in a jigsaw puzzle, and hopefully lead to a development of different objects that can be "jigsawed" for the market.

It has been assumed that for the target market that the jigsaw puzzle concept remains intact but extended in concept. In this definition, the pieces themselves are made from printed cardboard with a smooth external surface, as the bulk of retail jigsaw puzzles are. Also, the pieces themselves are similar in shape and size of a normal jigsaw piece and the clasping mechanism is the same. In other words, the jigsaw pieces look and feel familiar to a normal 2D jigsaw puzzle, albeit a little tweaked. It may be that in the development of the pieces and a 3D object jigsaw these pieces may not be as user friendly as hoped, and alternate medium and means of production would be looked at to achieve the end result. However, the point of note is that while the medium and production means may change, the concept does not; the pieces are designed specifically for surfaces that make up three-dimensional objects.

PIECES OF THE PUZZLE

The pieces are likely to have a standard clasping mechanism that a regular jigsaw puzzle would, i.e. male and female sections on alternate pieces. However, there is likely to be double the amount of clasps per side per piece and a much tighter fit between pieces to take into account the fact that the pieces will be covering 3D surfaces. There would be at least 5 different functional pieces.

1. A flat piece which would look like any other jigsaw piece that would have anywhere from 3–8 clasps. These pieces are roughly square shaped but could be triangular as required

2. A piece that folds around straight edges where two planes meet. It would have 4-8 clasps. This will be called Standard Double Piece.
3. A piece that allows for a curved surface. It would look like a flat piece that has been curved slightly. Again this would have 4-8 clasps and could be generally rectangular or triangular. This piece can be used for convex or concave surfaces. (These terms are used in reference to the external surface i.e. the surface that the eye sees.)
4. A piece that allows for a convex surface on one plane and a flat surface on another plane. This is another "double" piece and thus called a Convex Double Piece. This piece would have 4-8 clasps.
5. As 4., but a piece that allows for a concave surface on one plane and a flat surface on another plane, and resultingly called a Concave Double Piece. It would also have 4-8 clasps.

Standard Double Pieces

The overall shape of this piece can be described as placing two jigsaw pieces together and used where two edges meet that from two different flat planes, such as where two sides of a cube meet. Its fundamental difference to a conventional jigsaw piece is its ability to fold around the edge of the two planes. This is to be done by a fold line that has been pressed or grooved across the middle of the piece. This allows the piece to fold but in one direction only. (The folding of the piece would be done by the user prior to beginning the puzzle and would remain in this position for good.)

With just the standard double piece, all cube-like objects can be "jigsawed" .The function of the piece gives strength to the edge where the two planes meet; the two planes are physically joined together. The fold line is also a straight and clean edge, which in terms of aesthetics, has the advantage over finger-jointed 3D jigsaw puzzles.

However, it is more interesting when 3 planes come together. For a cube, for instance, there are 3 edges that meet where two sides and a top plane come together. Refer to drawing. Note that each of the corners where 3 edges meet, the standard double piece reinforce the corner by surrounding it; no one single piece takes all the stresses of the corner apex.

By extrapolation, an object like the letter "H" can be made, and so can the letter "A". The standard double piece does not have to be folded at a 90 degree angle but can be used for acute or obtuse surfaces. For instance, the top of the letter "A", where right and left sides of the pillars meet, would be covered by a standard double piece.

Curved Piece (Concave and Convex)

A curved surface piece is not much different than a normal flat piece that fills in broad areas of a surface, but the broad surface is curved. To make piece curve smoothly, the card is cut or grooved with lines that run parallel. This is done on one side only. (In the case of a convex curve this would be done on the underside of the jigsaw piece, and visa versa for a concave curve.) Once this is done the piece will have some degree of movement and in one direction only. Another way to visualize this is to imagine that corrugated cardboard in surfaced on one side only.

Using this type of cardboard, a jigsaw piece can be cut while the cardboard is flat. In other words, this not too far removed from the normal jigsaw manufacturing process.

Convex Double Piece

The fourth type of piece combines aspects and function of both the flat piece and the curved piece. Like the first double piece, it is also for an edge that joins 2 planes together; a convex surface meets a flat plane. Essentially, the piece combines grooved cardboard and the normal cardboard for its construction. The general shape of the Concave Double Piece is likely to be a square and a circle segment joined together at the apex of the curve of the circle segment. In other words, imagine a jigsaw piece that could be used for a coke can; a piece that covers the cylindrical section of the can, the curved edge, and the top section of the can where the ring-pull is. The square piece would be made for grooved cardboard so that it could follow the contour of the coke can. The circle would be made from flat cardboard so that it could be the flat end of a can.

It is important that the jigsaw piece is cut as one singular piece from a composite cardboard made from both the grooved and flat surfaces. There is also fold lines that have been pressed or grooved into the cardboard.

Compared to the first "double piece" the fundamental difference is that when the piece is folded along the fold lines so that it takes its desired edge shape, there is excess cardboard. In other words, if one imagines a circle and a square are placed next to each other, the circle will only touch the side of the square at the apex, not all the way along its circumference. The space that occurs where the circle's edge does not meet the square will be excess cardboard when the jigsaw piece is folded into its desired shape. To remove excess so that the piece takes on its curved edge, the excess folds under the jigsaw piece. This is initiated by fold-lines, which again are folded into place by the customer before beginning the puzzle. The excess cardboard is now folded out of view from the external surface.

Again, this piece could be cut as a flat piece like any other jigsaw piece.

Concave Double Piece

The Concave Double Piece is identical in concept as the previous jigsaw piece except that it is the reverse; this piece would be used where a concave surface meets a flat plane, such as where the inside of a bowl meets the edge of a bowl. Again, this piece would be cut from a composite card consisting of both grooved and flat card.

From the prototypes made, this piece is likely to be the most awkward in terms of user friendliness and function, keeping in mind that it is to be produced from a flat piece of card. While it effectively joins a concave curved piece of card with a flat plane, there is an amount of cardboard that would be designed to be removed by the user, so as the piece could fold together. In doing so, some of the strength of the piece might be compromised, or at minimum, the strength of the individual piece would have to be compensated by the jigsaw pieces surrounding it.

Once again this piece is to be designed so that it can be cut on a flat surface when manufactured.

Other Pieces

There may be other pieces required as standard pieces but the aim would be to minimize the different types of pieces. However, pieces might be introduced for special objects. For instance, there could be a need at some stage to have a double piece that is

made from entirely from the cardboard that curves. Another development might be a triple piece. Alternatively, given that there are inherent limitations to the surface and sheer tension, a jigsaw piece could be developed that enables monocoque structures to be built. Some of these pieces could really move the limitations of what can be "jigsawed"

PRODUCTION OF JIGSAW PIECES

With a 2D jigsaw, a cardboard picture is used, then placed under a standard die cutting press and cut into pieces. However, a 2D puzzle the pieces only have to slot together not contribute to a load bearing surface that a 3D structure will need. Thus the frictional resistance between the jigsaw pieces is paramount to the structural integrity. To gain enough surface tension between the pieces, the pieces simply have to be a tighter fit. The male and female parts of the clasps have to be cut with much finer tolerances than a standard 2D jigsaw puzzle.

LIMITATIONS

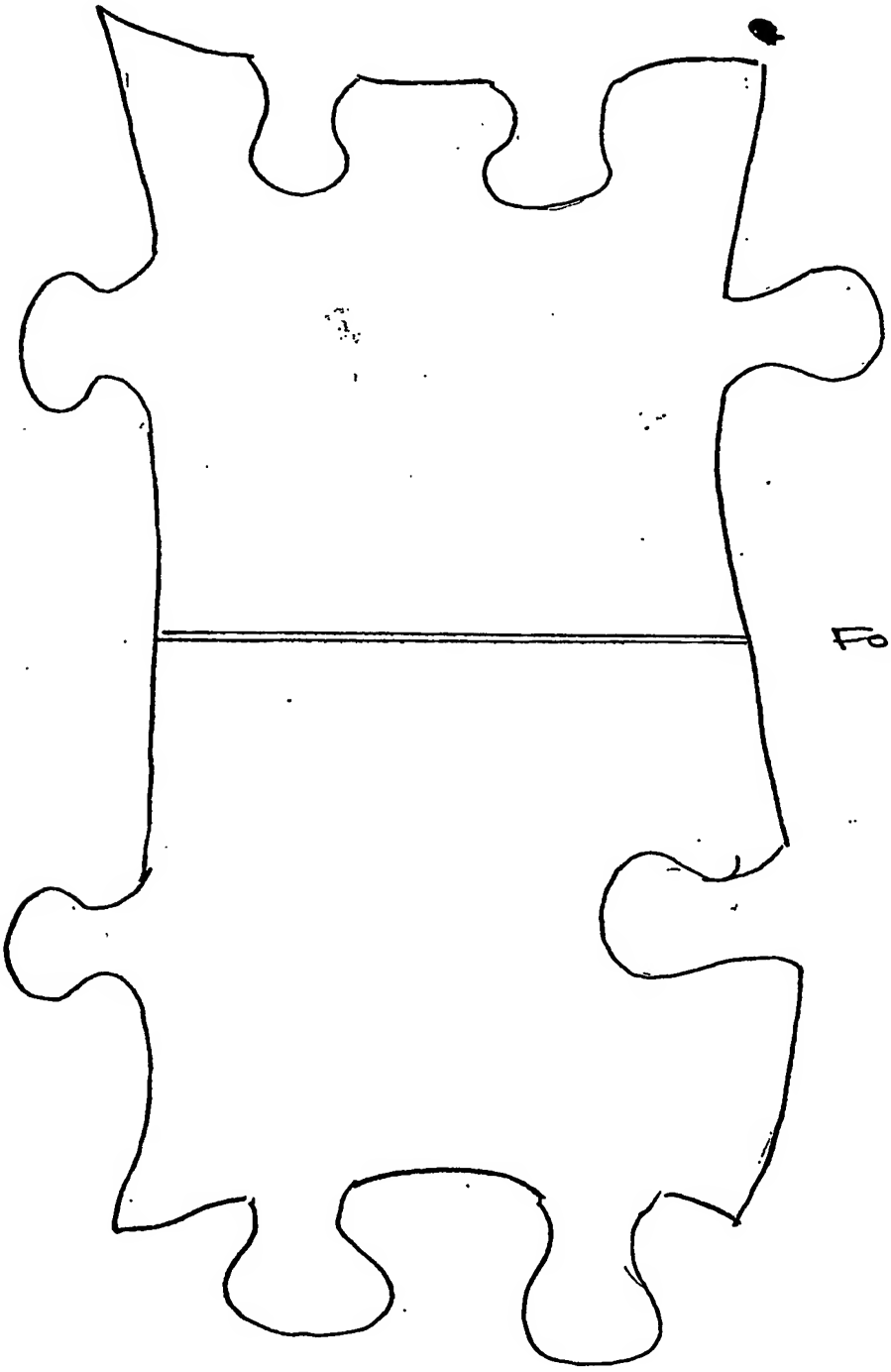
Although these jigsaws pieces extended the concept of a jigsaw puzzle, not all objects will be able to be "jigsawed". For some objects it will be obvious why they cannot be done and for others it will be a case of physics out weighing the imagination.

Also, the pieces themselves and the manufacturing process are intertwined in that pieces are not made independent of each other. It may be that some pieces may not easily, or cost effectively, be made. This might apply to pieces that are made from a composite flat and grooved cardboard. It may also be that there are ways to manufacture pieces using cardboard that do not have to be printed on a two dimensional template. For example, egg cartons are produced from a reconstituted paper that is pressed into shape.

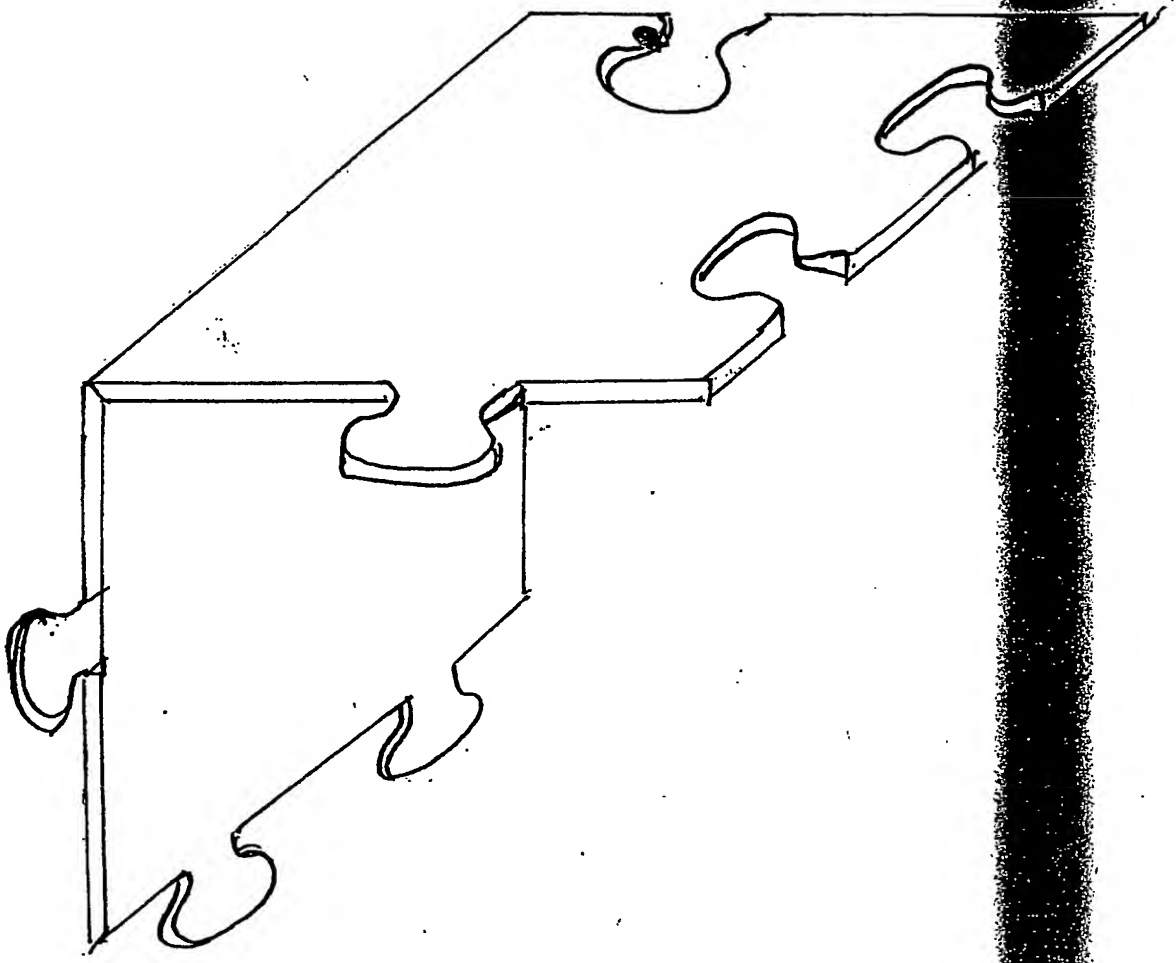
There may be problems encountered with the clasping mechanism, especially joining pieces that are in the middle of a curved surface. Although it is hoped that having double the amount of clasps per side will increase the surface tension, and frictional resistance between the pieces through a tighter fit will be able to form a stable structure.

These are the type of problems that will have to be recognized during a product development stage.

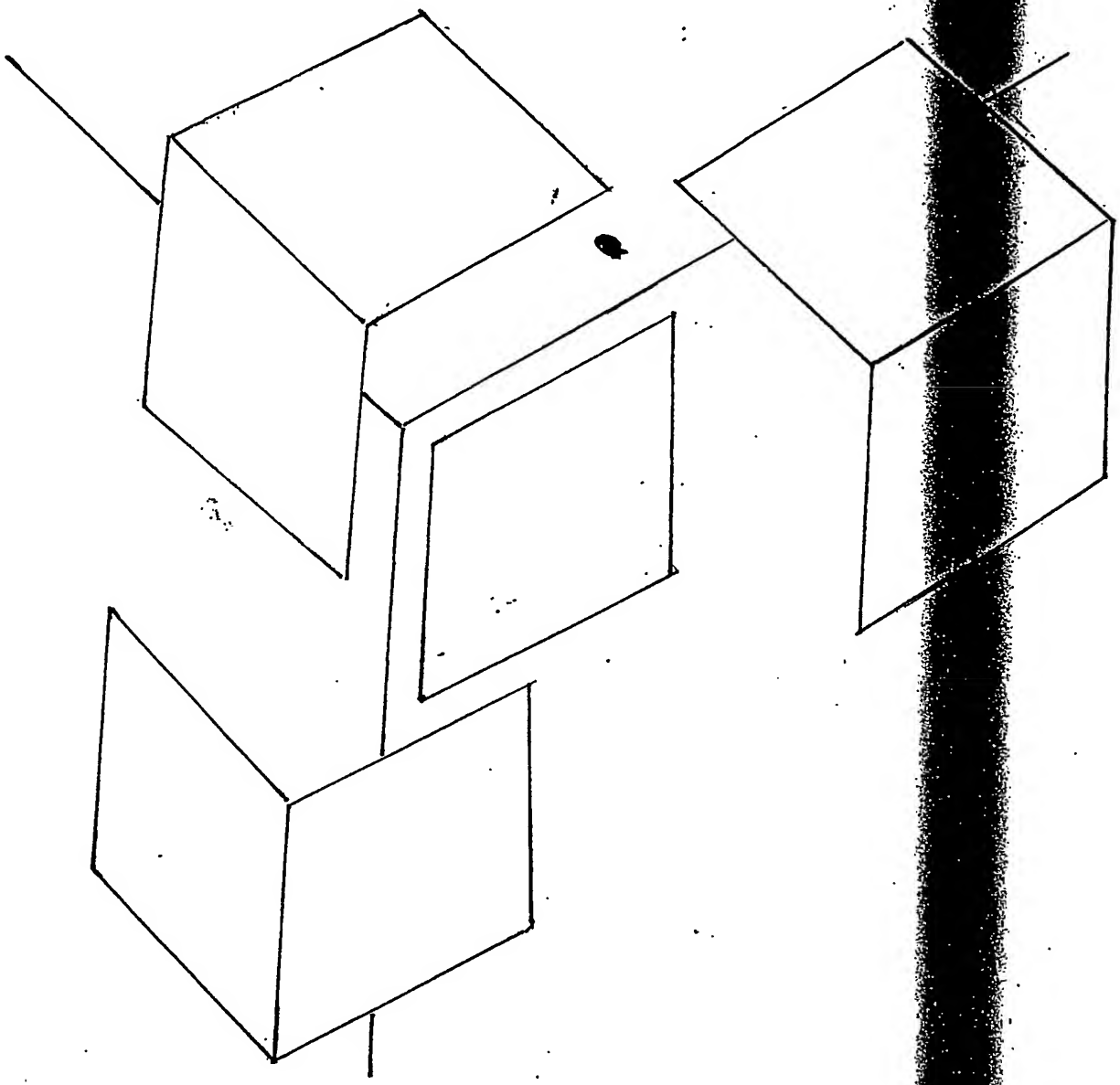
SCHEMATIC DIAGRAM OF STANDARD DOUBLE PIECE



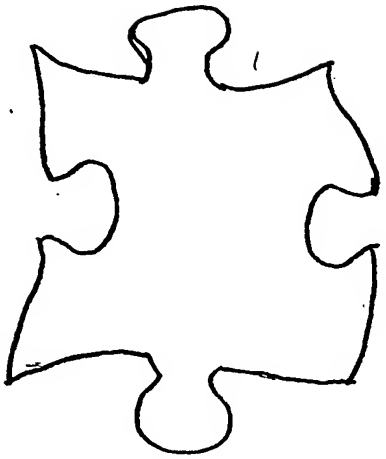
SCHEMATIC DIAGRAM OF STANDARD DOUBLE PIPE-T
(FOLDED)



SCHEMATIC DIAGRAM OF HOW DOUBLE PIECES WOULD BE USED WHERE 3 PLANES MEET.



GRAM OF CURVED PIECES.



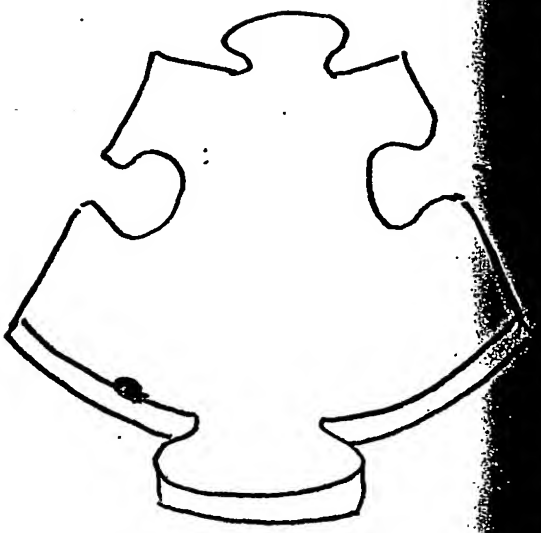
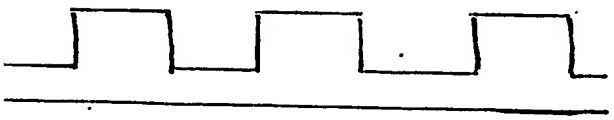


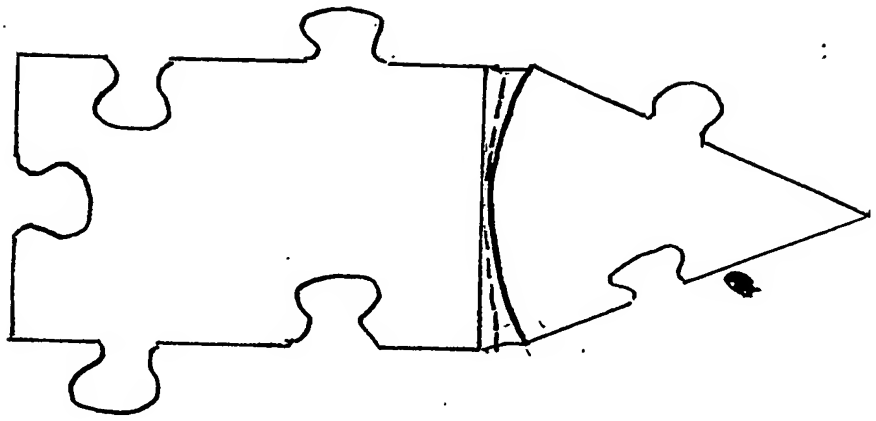
DIAGRAM OF GROOVES EMBEDDED IN CURVE PIECE

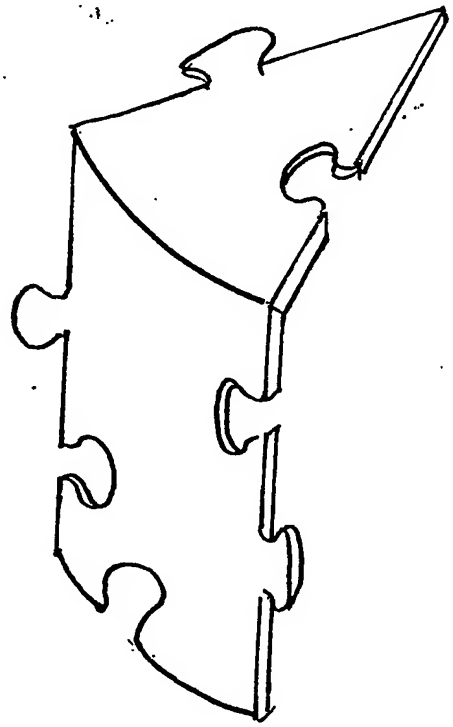


EXPAND SECTION OF CARDBOARD

(V)

SCHEMATIC DIAGRAM FOR CONVEX DOUBLE PIECE





SCHEMATIC DIAGRAM FOR CONCAVE DOUBLE PIECE